Multi-Aspect Young ORiented Advanced Neutrino Academy
School&Workshop - II edition

The first neutrino mass limit of HOLMES

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On behalf of HOLMES collaboration

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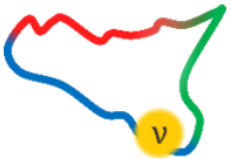
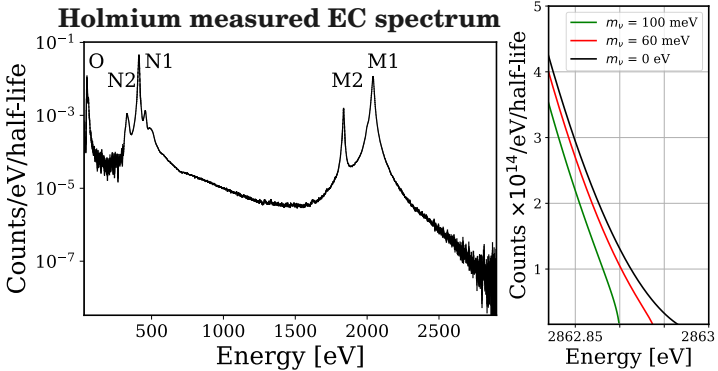


The HOLMES experiment

- Measuring the **neutrino mass** is of crucial importance;
- **Model-independent** method: energy conservation;
- KATRIN best limit: $m_\nu < 0.45$ eV 90% C.L. (^{3}H source outside the detector);
- **HOLMES**: ^{163}Ho source embedded inside the detector.

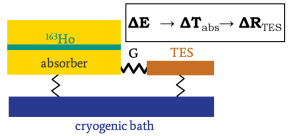
Holmium electron capture:

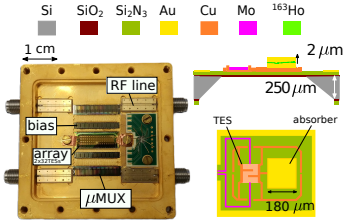
$$^{163}\mathrm{Ho} + e^- \rightarrow {}^{163}\mathrm{Dy}^H + \nu_e$$
$$^{163}\mathrm{Dy}^H \rightarrow {}^{163}\mathrm{Dy} + E_C^H$$



Experimental setup

- **HOLMES** is an experiment located in Milano-Bicocca laboratories;
- **Low temperature** ($\sim$ 60 mK) **microcalorimeters**;
- ^{163}Ho implanted **Transition Edge Sensors** each coupled to a gold absorber;
- Multiplexed TES 64-pixel array ($\sim$0.3 Bq/pixel);
- $\Delta E_{FWHM} \in [5, 7]$ eV;
- Gradual approach based on **scalability** for an experiment with 0.1 eV m_ν sensitivity.





The ROI fit

- **Bayesian parameter estimation**;
- Poisson likelihood and a modeled spectrum;
- Posterior explored using Hamiltonian MCMC via STAN;
- Q: free parameter.

Spectrum @ ROI [2250,3500] eV:

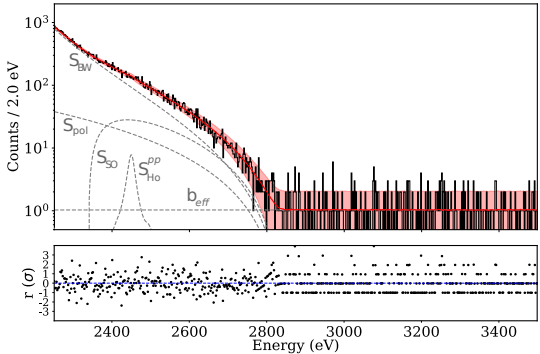
$$\mathcal{S}_{\text{exp}} = \left[N_{tot} \left(\mathcal{S}_{\text{Ho}} + f_{eff}^{pp} \mathcal{S}_{\text{Ho}}^{pp} \right) \right] * \mathcal{R}_{eff} + b_{eff}$$

$$\mathcal{S}_{\text{Ho}} \approx k_0 \left(k_{\text{BW}} \mathcal{S}_{\text{BW}} + k_{\text{SO}} \mathcal{S}_{\text{SO}} + \mathcal{S}_{\text{pol}} \right) \times \mathcal{F}_{\text{PS}}$$

$\mathcal{F}_{\text{PS}}$: phase space, only term with m_β

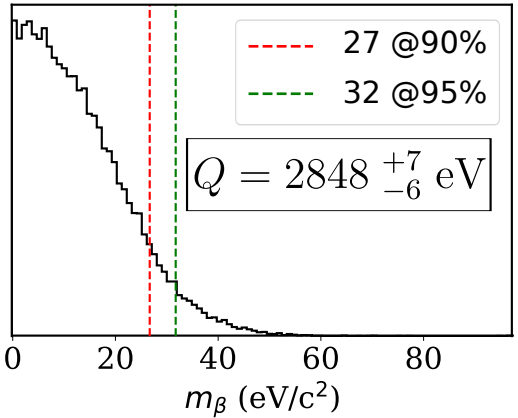
$$\propto (Q-E)\sqrt{(Q-E)^2 - m_\beta^2}$$

Measured and fitted spectrum @ROI



The neutrino mass limit

- With 15 Bq, 48 channels, 2 months, we established $m_\beta < \mathbf{27\ eV/c^2}$ (90% CI);
- **Most stringent bound** on m_β ever obtained from EC decay of ^{163}Ho;
- m_β posterior distribution:



Conclusions

- HOLMES performs a **calorimetric** measurement of ^{163}Ho EC spectrum in a **cryogenic** environment;
- The result on m_β (< 27 eV/c^2 (90% CI)) confirms the **feasibility** of the method;
- Future **scaling** of the experiment aims to reach **sub-eV sensitivity**;
- **HOLMES+**: next-gen neutrino experiment module under development.

Thank you for your attention!

Scan the QR code to read our **new article**:
"Most stringent bound on electron neutrino mass obtained with a scalable low temperature micro-calorimeter array"